

OUR ASTRONOMICAL COLUMN.

REFRACTION AND THE APPARENT DIURNAL MOVEMENTS OF STARS.—The question of the apparent change of positions of stars due to refraction as the hour angle varies, becomes of importance when long intervals of time are taken into account. In photographing the stars, it is generally usual to "stand by" and make all the necessary small adjustments, due to atmospheric refraction, with the hand. A method has, however, been recently suggested and worked out by Dr. A. A. Rambaut, by which the rate of the driving clock may be so adjusted as to take into account these minor discrepancies when a high state of accuracy is desired for stars at large hour angles (*Monthly Notices*, vol. lvii. No. 2). This method does not, of course, take into consideration local or temporary changes in the refraction, but the perfectly regular and systematic change as the star increases or decreases its altitude. For a telescope to follow a star with absolute precision, a clockwork must be constructed which would drive the instrument at an ever-varying rate according to the formula given by Dr. Rambaut. This, however, cannot be practically achieved, and would, further, be unnecessary, as a close approximation is all that is needed in practice. By a system of curves obtained from the above-mentioned formula, and treated graphically, it has been found that a uniform rate, *if suitably chosen*, will not in ten minutes introduce an error amounting to one-twentieth of a second, which is within the limits of the accidental errors of a good equatorial clock. By prolonging the exposure beyond the period for which a uniform rate is admissible, the rate must be altered to one now more suitable. A series of weights, skilfully employed in controlling the action of a pendulum in connection with the driving clock, will allow the different rates to be easily produced. Dr. Rambaut describes a graphical method for obtaining the length of exposure during which a uniform rate may be used. This he finds most convenient in practice for short exposures, and he relates that he can turn his telescope, with the greatest confidence, from a star at its upper culmination, to follow which a star must lose at the rate of from 18 to 100 seconds or more a day, and one at its lower culmination, gaining at the rate of 70 or 80 seconds a day, and he finds "the telescope will follow both with equal accuracy." It may be remarked that this method is practically intended to be utilised when photographs for the detection of stellar parallax are in question, as it is only then that they must be obtained when the stars have a considerable hour angle.

"BULLETIN ASTRONOMIQUE DE FRANCE."—The April number of this monthly contains, among other things, an interesting article, by Camille Flammarion, on the planet Venus, more special attention being paid to the observations which have indicated the presence of an atmosphere. There is also an account of Mr. Percival Lowell's recent observations on the surface markings, and the subsequent determination of the period of rotation, mentioned previously in this column. *A propos* of our note last week, on the question of the adoption of France of Greenwich time, we find that the following resolution was voted by the assembly at the meeting of the French Astronomical Society, on March 3 last, the proceedings of which are here recorded:—"La Société astronomique de France, considérant qu'au Congrès de Washington la proposition du méridien de Behring, qui avait un caractère éminemment géographique, impersonnel et d'ordre universel, n'a pas été adoptée, ne juge pas à propos d'en adopter un autre, qui n'a à aucun degré le caractère auquel la France est toujours restée fidèle dans les réformes dont elle a pris l'initiative." This number of the *Bulletin* contains also several communications relating to the moon, and another beautiful reproduction from one of Loewy and Puiseux's lunar negatives is given, which, for amount of detail and fine contrast, is strikingly beautiful.

PROF. EDUARD HAERDTL.—The Professor of Astronomy at Innsbruck, Prof. Eduard Freiherr von Haerdthl, whose death (*Astr. Nach.*, No. 3416) we regret to record, was born in the year 1861 at Penzing, near Vienna. After finishing his Gymnasium studies in 1880, he selected mathematics and astronomy as his chief pursuits at the Vienna University. He was one of the most apt pupils of Th. von Oppolzer, whose work he vigorously took up, and afterwards so ably continued. In 1892 Haerdthl was promoted to the Professorship of the Innsbruck University. Endowed with a great capacity for carrying out astronomical computations, his dissertation "Beiträge zur Assyrischen Chronologie" was followed by other publications,

chief of which was the investigation of the movement of Winnecke's comet. The prize of the Copenhagen Academy of Sciences he won with an interesting essay, entitled "Skizzen zu einem speciellen Fall des Problems der drei Körper," after which he busied himself with the terms of long period in the movement of the moon, and shortly before his death with Winnecke's comet again. Full of such promise, and cut off at the early age of thirty-six, not only has astronomical science lost a man who seemed destined to enrich her with many valuable contributions, but his circle of friends mourn the loss of a kind and true "Kamerad."

ON ELECTRICAL PROPERTIES OF FUMES PROCEEDING FROM FLAMES AND BURNING CHARCOAL.¹

§ 1. MANY experimenters have investigated the electrical properties of flames and incandescent solids. The methods usually employed have been (1) to examine the electric conductivity of different parts of the flame;² (2) to measure the difference of potential between platinum wires in different positions in the same flame;³ (3) to find the leakage of a charged conductor when placed near, or in view of, a flame or an incandescent solid;⁴ (4) to observe the leakage of a conductor, raised to a red or white heat, by an electric current, and electrically charged while it is surrounded by different gases;⁵ and (5) to observe the production of electrification or diselectrification by a glowing wire, through which a current is passing, in neighbouring insulated conductors separated from it by different gases.⁶

§ 2. This short communication divides itself into three separate inquiries: (1) to test by one of our electric filters⁷ the electric quality of the fumes from different flames and burnings (this method has not, we believe, been tried before); (2) to observe the difference of potential between a copper plate and a zinc plate when the fumes from different flames and burnings at different distances from the plates passed between them and round them; and (3) to observe the leakage between two parallel metal plates with any difference of electric potential when the fumes from flames and burnings were allowed to pass between them.

§ 3. To test the electrification of fumes from different flames and burnings, the arrangement shown diagrammatically in Fig. 1 was used. The flame is kept burning at the mouth of a large vertical iron funnel A, closed at its upper end; and the heated air, along with the products of combustion, is drawn off by an air-pump through a small aperture, B, near the upper end. Before reaching the pump the air has to pass through three circular pieces of brass wire gauze, D, one centimetre apart, which are fixed across the funnel about 5 centimetres below the exit tube B; and through a worm of block-tin pipe, 90 centimetres long, which is kept surrounded by cold water in a vessel C. The electrification was tested by a quadrant electrometer (sensitiveness of the electrometer 111 scale divisions per volt), and an electric filter F. The filter F was of block-tin tube, 5 centimetres long and 1 centimetre bore, and full of fine brass filings kept in position by a plug of cotton-wool and a piece of brass wire gauze at each end. Between the filter and the air-pump is a T-shaped piece of glass tubing with lower end of the vertical tube dipping into a basin of mercury. This served as a pressure gauge to indicate the difference of air pressures on the two sides of the filter when the air-pump was worked. The flame, the iron funnel, the worm, and the case of the electrometer are all metallicityally connected.

¹ By the Right Hon. Lord Kelvin, G.C.V.O., F.R.S., and Dr. Magnus Maclean. Paper read at a meeting of the Royal Society, Edinburgh, on April 5.

² Account of experiments in Wiedemann's "Lehre von der Elektricität," vol. iv. B. Carl's *Rep.*, xvii. pp. 269-294, 1881. J. J. Thomson, *Phil. Mag.*, pp. 358, 441, 1890.

³ Hankel, *Phil. Mag.*, p. 542, December 1851; *Phil. Mag.*, p. 9, January 1860. Elster and Geitel, *Wied. Ann.*, vol. xvi., 1882; also *Phil. Mag.*, September 1882. Maclean and Goto, *Phil. Mag.*, August 1890.

⁴ Guthrie, *Phil. Mag.*, p. 308, April 1873. Giese, *Wied. Ann.*, vol. xvii. Schuster, Lecture Royal Institution, February 22, 1895.

⁵ Guthrie, *Phil. Mag.*, p. 237, October 1873.

⁶ Elster and Geitel, *Wied. Ann.*, xxxvii. p. 315, 1889; Elster and Geitel, *Wied. Ann.*, xxxviii. p. 27, 1889.

⁷ Kelvin, Maclean, Galt, "Electrification and Diselectrification of Air," *Proceedings of the Royal Society, London*, vol. lvii., February and March 1895; also B.A. Report, 1895.

§ 4. The following flames and burnings were tried :—

- (1) Candle.
- (2) Paraffin lamp.
- (3) Spirit flame.
- (4) Portable electrometer matches.
- (5) Coal-gas (Bunsen flame).
- (6) Hydrogen flame.
- (7) Glowing charcoal.
- (8) Glowing coals.

§ 5. The method of experimenting was to place the burning substance in position at the bottom of the funnel, to insulate the quadrant of the electrometer in connection with the electric filter, and to start working the air-pump at the rate of one stroke per three seconds. The time of each experiment was ten

the long vertical tube through which the acid was admitted, indicated the pressure under the nozzle, above which the hydrogen was burning.

§ 6. In the case of the charcoal and coal, the burning fuel was placed at the bottom of the iron funnel in a thin rectangular metallic vessel with small holes perforated in the bottom and in the sides. A wire from the case of the electrometer passed through one of these holes, and was thrust into the burning fuel. It was noticed that when the burning charcoal was first put in position below the funnel it always produced negative electrification, which ultimately changed to positive. Thus, in four experiments, the electrification, which was at first negative, became positive after 8, 10, 14, and 18 minutes respectively. On investigation it was found that as long as any flame¹ was visible in the burning charcoal the electrification was negative ;

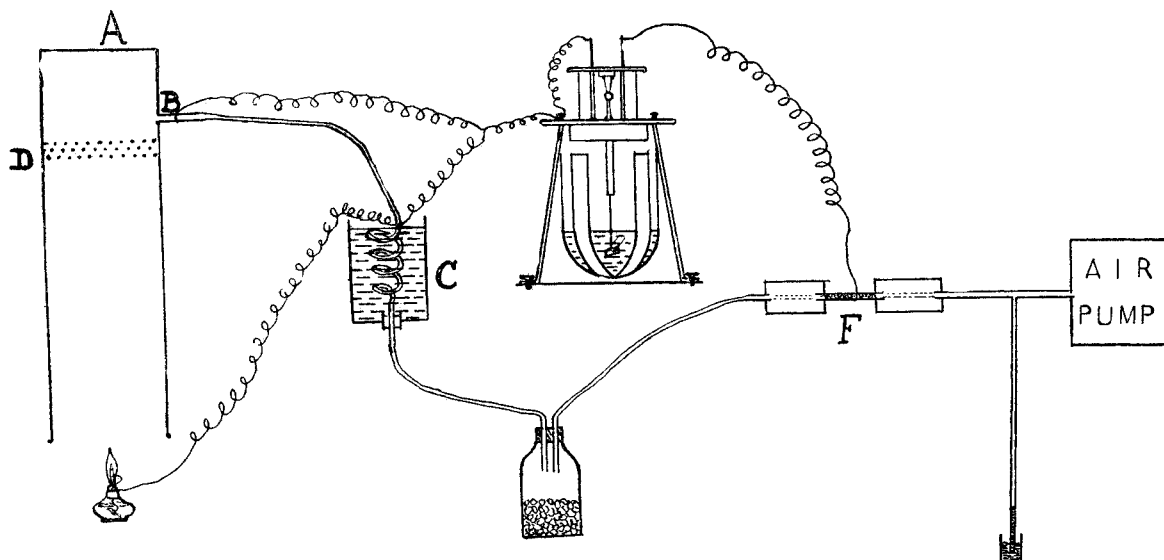


FIG. 1.

minutes (200 strokes of the air-pump). The results obtained are given in the following table. In testing the electrometer

Sensitiveness of the electrometer, 111 scale divisions per volt.

	Number of experiments.	Mean deflection in scale divisions of electrometer.	Potential in volts.
(1) One candle	2	90 neg.	0·81 neg.
(2) One paraffin lamp ...			
(a) without glass funnel	2	84 „	0·76 „
(b) with glass funnel ...	2	30 „	0·27 „
(3) One spirit lamp	4	109 „	0·99 „
(4) Four portable electrometer matches ...	2	224 „	2·03 „
(5) One Bunsen flame ...	4	30 „	0·27 „
(6) One hydrogen flame			
At low pressure gave small negative; at higher pressures large positive. No electrification was found from the jet at any pressure when not burning.			
(7) Charcoal	}	Both gave negative electrification when there was a flame ; and both gave positive electrification when they were glowing without flame.	
(8) Coals			

matches, four matches were stuck in holes in a metallic plate, and the plate connected by a wire to the case of the electrometer. These matches, according to a suggestion made more than thirty years ago by Faraday, are made of white blotting-paper soaked in a solution of nitrate of lead, and rolled up with paste into little rods of about five millimetres diameter. The hydrogen was generated in an ordinary Woulfe's bottle from zinc and hydrochloric acid. The rise of the dilute hydrochloric acid in

but as soon as all the flame disappeared, leaving only the red glow, the electrification became positive. To test this the heated

¹ In a paper on "Electrification of Air by Combustion," by Magnus Maclean and Makita Goto, communicated to the Philosophical Society of Glasgow on November 20, 1889, is a statement of results of many observations to find the potential to which the insulated quadrant of a quadrant electrometer is raised when in metallic connection with various kinds of flames and fires. It is there said : "The effect of an ordinary lucifer match is very interesting. While the match is burning with a flame the deflection indicates positive electrification ; but after the flame ceases the electrification becomes negative, the effect now being that of glowing charcoal." The following table is quoted from the paper. In some cases the burnings lasted so short a time that quantitative determinations of the potential were not obtained. It is *conceivable* that all of the complementary opposite electricity separated from that which went to the electrometer in those experiments went to uninsulated solids in the neighbourhood. The experiments described in the text demonstrate that some of it was lodged in the air and fumes proceeding from the fire or flame.

Substances giving flames or burnings.	Electrification of insulated fuel.	Greatest observed potential in volts.
Charcoal	Negative	3·0
Lucifer match, wood, and paper glowing		3·0
Hydrogen		0·6
Iron burning in vapour of sulphur		—
Copper	Positive	—
Paraffin lamp		0·6
Alcohol lamp		0·3
Sulphur		2·0
Phosphorus exposed to air ...		1·5
Magnesium		—
Iron burning in oxygen		—
Lucifer match, wood, and paper burning with flame		—
Bisulphide of carbon		0·6
Sulphuric ether		0·9
Turpentine		0·5
Bees-wax		0·7
Camphor		—

charcoal was kept away from the funnel till all flame had disappeared. Then the vessel was put in position, and the deflections obtained in two experiments were—

51 scale divisions positive in 10 minutes.
100 " " " " "

§ 7. Next an experiment was made with the burning charcoal put in position while a flame was visible. The flame remained visible for 7 minutes, and in that time a negative electrification of 34 divisions was obtained. Then the deflection came back to the metallic zero in one minute, and in 10 minutes more a

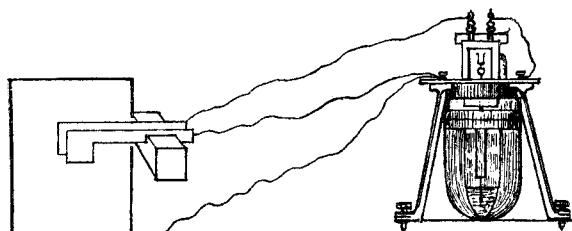


FIG. 2.

positive electrification of 87 divisions (0·78 volts) was obtained.

§ 8. Glowing coals taken from the fire and put at once in the vessel in position, repeatedly gave negative electrification; but when they were kept away from the funnel till all flame had disappeared, the electrification obtained was slightly positive. Glowing coals remained glowing a very short time after all flame ceased, and the smallness of the observed effect is probably due to this cause.

§ 9. A few experiments have also been tried to find to what positive potential the flame must be raised so as to overcome the negative electrification it gives to the air. Hitherto the only flame tried was a spirit flame. The positive electrode of a secondary cell was put into the flame of the lamp, and the negative electrode was joined to the iron funnel and to the case of the electrometer.

The results obtained are not very regular,

but we found that one storage cell was not sufficient to overpower the electrifying effects of the spirit flame. With one cell we got 45 divisions negative in 10 minutes, instead of 109 divisions with metallic connection; with two cells we got 10 divisions positive in 10 minutes; and with six cells we got 83 divisions positive in 4 minutes.

§ 10. The filter, pump, and worm were now removed, and two plates—one of polished copper, and the other of polished zinc—were fixed 0·9 centimetre apart in a block of paraffin, as represented in Fig. 2. The arrangement was such that either plate could be insulated, while the other was kept in metallic connection with the case of the electrometer. Observations were made to find the deflection from metallic zero with one plate insulated, and fumes from different flames and burnings at different distances from the plates passing up between them. This may be called the fumes-zero. When the top of the flame was within 5 or 6 centimetres from the plates, the results were very irregular. The results in the following table for spirit flame are in accordance with what Maclean and Goto obtained from unguarded fumes from a spirit lamp 30 centimetres below the plates, as stated in their paper published in the *Philosophical Magazine* for August 1890. The effect is of the same kind as if the plates were connected by a drop of water.¹

Sensitiveness of the electrometer 136 scale divisions per volt.

Flame.	Distance of top of flame below the plates in centimetres.	Metal connected to insulated terminal of electrometer.	Difference between fumes-zero and metallic zero in scale divisions.	Potential in volts.
Spirit lamp ...	23	Copper	81 pos.	0·60
" ...	"	Zinc	101 neg.	0·74
" ...	11	Copper	53 pos.	0·39
" ...	"	Zinc	76 neg.	0·56
Paraffin lamp without glass funnel ...	7	Copper	141 pos.	1·04
" ...	"	Zinc	138 neg.	1·01
" ...	15	Copper	90 pos.	0·66
" ...	"	Zinc	103 neg.	0·76
" ...	23	Copper	108 pos.	0·79
" ...	"	Zinc	112 neg.	0·82
" ...	30	Copper	83 pos.	0·61
" ...	"	Zinc	83 neg.	0·61

§ 11. To observe the leakage between two parallel metal plates, the zinc plate was removed, and a polished copper plate, equal and similar to the other copper plate, was substituted for it. The distance between their parallel planes was 0·9 cm. The experiments were conducted as follows: One pair of quadrants of the electrometer, with one of the copper plates in metallic connection with it, was insulated. There was now no deviation from metallic zero. A small charge, positive or negative, was given to it, producing a deflection of about 450 scale divisions. This corresponds to over 9 volts, as the sensitiveness of the electrometer now used was 48·2 scale divisions per volt. In two or three minutes the ordinary leakage of the arrange-

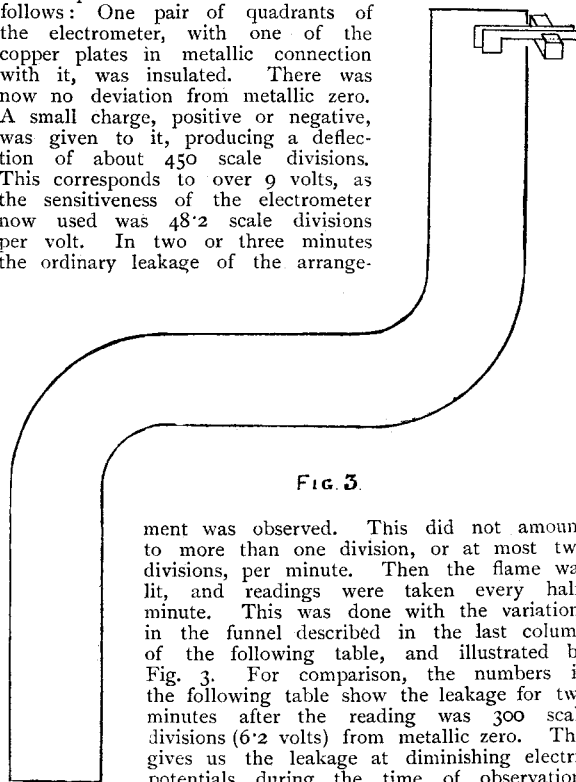


FIG. 3.

ment was observed. This did not amount to more than one division, or at most two divisions, per minute. Then the flame was lit, and readings were taken every half-minute. This was done with the variations in the funnel described in the last column of the following table, and illustrated by Fig. 3. For comparison, the numbers in the following table show the leakage for two minutes after the reading was 300 scale divisions (6·2 volts) from metallic zero. This gives us the leakage at diminishing electric potentials during the time of observation.

We intend to continue these experiments, and to arrange to find the leakage at different constant electric pressures.

§ 12. The marked difference in the leakage obtained when the horizontal tube was of small bore (3·8 cms.) and when it was of larger bore (15·3 cms.), may be contrasted as indicated in the last four results given for spirit flame. We also tried how long the fumes retained this conductive quality, but in every case we found that the leakage stopped in less than a quarter of a minute after the flame was extinguished, or removed from the bottom of the funnel. Closing the top and bottom of the funnel immediately after the flame was removed, we still found that the

¹ Kelvin, 'Electrostatics and Magnetism,' §§ 413 414, pp 332, 333.

± 300 scale divisions, equivalent to 6.2 volts, to begin with in each case.

Flame.	Length of funnel between burning substance and copper plates.	Leakage in two minutes.	Remarks.
Spirit flame	Centimetres. 66	Scale divisions. 292 pos.	Funnel of 15.3 cm. bore all vertical.
"	"	287 neg.	" " "
"	112	253 pos.	" " "
"	"	254 neg.	" " "
"	343	22 pos.	Funnel 114 cms. vertical of 15.3 cms. bore; and 229 cms. horizontal of 3.8 cms. bore.
"	"	20 neg.	
"	236	24 pos.	Same vertical, and 122 cms. horizontal of 3.8 cms. bore.
"	"	20 neg.	
"	160	40 pos.	Same vertical, and 46 cms. horizontal of 3.8 cms. bore.
"	"	46 neg.	
"	244	165 pos.	Same vertical, and 130 cms. horizontal of 15.3 cms. bore.
"	"	187 neg.	
Charcoal	"	54 pos.	" " "
"	"	57 neg.	" " "

conductive quality of the air and fumes ceased within a quarter of a minute.

§ 13. In connection with these last experiments, attention may be directed to an experiment described by Prof. Schuster, in which he uses an insulated metallic tube bent round at the upper end, to prove that "it is not only the flame itself which conducts, but also the gases rising from the flame."¹ He discovers electric conductance in products of combustion mixed with air quite out of sight from the flame.

SURVEY OF THE TIDES AND CURRENTS IN THE GULF OF ST. LAWRENCE.

WHEN the meeting of the British Association was held at Montreal in 1884, the necessity of establishing stations for tidal observations in Canadian waters was discussed, and the Association adopted a resolution drawing the attention of the Government of the Dominion to the matter. A committee was also appointed to collect information and make representations to the Government respecting it. Two years later a large deputation, representing the British Association, the Royal Society of Canada, and the Board of Trade of Montreal, waited on the Minister of Marine. The matter was favourably received, but, owing to financial reasons, any action was for the time postponed. In 1889, however, exploratory trips were undertaken, by direction of the Government, with the view of ascertaining the best points to establish tide gauges; and in 1890 a practical commencement of the survey of the tides and currents in the Gulf of St. Lawrence was made. The object of this survey is to furnish data for compiling trustworthy tide-tables, and to afford information as to the set of the tidal and other currents in the Gulf. The value of such information is shown by the remarks of Lieut. Gordon in his report to the Minister of Marine, in which he expresses the conviction that until an exhaustive examination of the whole system of tidal movements carried out on similar plans to those which have been made on the United States coasts, and on the coasts of Great Britain, has been made, there will always be the liability to heavy maritime losses due to the lack of information. The average loss, he states, is now over half a million of pounds—a large proportion of which is due to a want of knowledge of the currents.

For the purpose of determining the set and cause of the

currents, it was necessary to have a trustworthy record of the time and range of the tides; of the variation in the pressure of the barometer; the force and direction of the wind; and the temperature and density of the water at different depths. The survey is under the charge of the Marine Department, with Colonel Anderson, Chief Engineer, at the head. The tidal survey is in charge of Mr. W. Bell Dawson, C.E. Four reports as to the progress of the work have already been issued. In the first season the two entrances to the Gulf were examined at Belle Isle and Cabot Straits, between Cape Breton and Newfoundland; and the general relation of the Gulf to the ocean as regards tide and currents was examined. Next season the entrance between the Gaspé coast and Anticosti was examined, and the nature of the currents was traced across the south-western side of the Gulf to Cape Breton. This part of the Gulf is a steamship route of constantly increasing importance. More recently, the north-eastern arm of the Gulf, from Anticosti to Belle Isle, through which passes all the Atlantic traffic which takes the Belle Isle route, has been under examination. Seven self-recording tide gauges have also been set up, the establishment of the intended stations on the Atlantic coast having been postponed owing to the want of funds. Although the shortest time for obtaining a correct computation of the tides at any port is the lunar cycle of nineteen years, sufficient data have been collected to enable the Department to issue tide-tables for the use of the pilots of the St. Lawrence, and for Halifax.

It has been settled that the current in the Strait of Belle Isle is fundamentally tidal; and, under normal conditions, runs east and west, with velocities of about two knots in each direction. During heavy winds, especially when westerly, the current which runs with the wind becomes stronger than the current against it; and for a time the current may become continuous in the same direction as the wind.

The tides vary in height from four to five feet in the open Atlantic, to twelve feet in the lower part of the St. Lawrence River, seventeen feet at Quebec, and thirty feet over the Bay of Fundy. To correctly observe these, tide gauges fixed at different parts of the coast are required. Owing to the uninhabited condition of a great part of the coast, the difficulty in selecting suitable places and attending to the gauges has been very great. The self-recording gauges used are of the usual design, but special precautions have had to be taken to guard against the effect of ice and the oscillation due to wave action. At most stations no wharves or quays were available against which the gauges could be fixed. At some of the stations wells had to be sunk at high-water mark to the level of the lowest tides, and a trench, 270 feet long and 10 feet deep, excavated across the rock shore, to admit the tide to the well. The tide was led to the well by wooden piping, made from fir trees, twelve inches diameter, having a hole three inches in diameter bored through the centre, the joints being made tight with sail-cloth saturated with white lead. To prevent the effect of air entering the pipes, due to the surge of the sea in rough weather, an iron pipe was laid out along the bottom for about 100 feet, into water having a depth of twelve feet at the lowest tides. To prevent freezing in winter, a boiler, three feet in diameter, was placed vertically in the well and kept heated, and in this the tide pipes were fixed. These gauges have been occasionally damaged during gales, and in one case the station could not be reached between January and the opening of the navigation in May. At some of the stations, situated on islands, it was necessary to make a telegraphic exchange of time once a week to regulate the driving clocks. To avoid this expense, meridian instruments, named *dipleidoscopes*, have been employed, which, when once set correctly, give the exact time of the sun's meridian passage. These were obtained from a Paris maker.

The currents in the Gulf are affected both by the tide and the amount of fresh water coming down the river. It was found that the under-currents which exist are frequently displaced and brought nearer the surface, either by the effect of wind or by a variation in the temperature. For the purpose of ascertaining the position and force of these currents observations were taken as to their flow, and also as to the temperature and density of the water. From Quebec to Father Point the tidal current occupies the whole width of the river; when the channel widens, a part of it is occupied by a constant downward current which runs parallel to the south shore all the way to Gaspé. The main tidal current enters the Gulf from the Atlantic by Cabot Strait, between Cape Breton and Newfoundland, and does not lose itself in the great expanse of the Gulf, but continues across

¹ Prof. Schuster, on "Atmospheric Electricity," at Royal Institution, February 22, 1895.